MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

ETM3136 – DIGITAL COMMUNICATIONS

(TE)

23 OCTOBER 2017
09:00 a.m – 11:00 a.m
(2 Hours)

INSTRUCTION TO STUDENTS

1. This question paper consists of 7 pages with 4 Questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

Multimedia University hired you as a telecommunication engineer to design telecommunication system between CyberJaya campus and Melaka campus. An existing optical fiber with bandwidth 34.2MHz will be used for a purpose of landline telephone communication between the two campuses. As a user makes call, an audio signal with baseband bandwidth 9 KHz and 0.75V peak amplitude, will be digitized by 6-bit encoder. To avoid any intersymbol interference, raised-cosine pulse with a 90% roll-off factor should be used. Too many signals can be combined by a technique and occupy 2.85MHz of bandwidth in the optical fiber line. The following parameters should be presented to MMU before the installation:

(i) What multiplexing technique will you use for this application? [1 mark]
(ii) What is the transmit data rate? [2 marks]
(iii) Considering you are using uniform quantizer, how many levels does this quantizer have? [1 mark]
(iv) What is the value of the quantization error? [2 marks]
(v) How many channels does your system accommodate? [2 marks]
(vi) What is the data rate of each signal? [2 marks]
(vii) What is the minimum sampling rate? [2 marks]
(viii) What is the real sampling rate? [3 marks]
(ix) Draw the block diagram using the technique you used in section (1). Indicate the following parameters, such as sampling rate, data rate. No synchronization bits were added. [2 marks]
(x) Consider only one synchronization bit per frame, and the switch of the technique you used in section (1) picks up one bit from each user. Draw the frame and indicate the following parameters bit period, frame period, frame rate, number of bits per frame and the new data rate. [2 marks]
(xi) How much in terms of percentage the real sampling rate above the minimum sampling rate? [3 marks]
(xii) What is the signal to noise ratio (SNR) of each transmit signal? [2 marks]
(xiii) What is the signal to quantization noise ratio (SQNR)? [1 mark]

Continued...

Question 2

Consider a system uses an advanced modulation technique to modulate digital signal with baseband bandwidth 20MHz. In addition, to avoid the intersymbol interference, the system uses raised cosine spectrum with roll-off factor 90%. As a telecommunication engineer you have to options two send the modulated signal:

(i) Use wireless channel to send the signal over a license of 10MHz bandwidth by Malaysian communications and multimedia commission (MCMC). What kind of modulation the system should use to fit the channel bandwidth? How much of bandwidth saving in Hz if 64QAM modulation is used to send the data.

[10 marks]

(ii) Use pseudo noise (PN) sequence with code length of 128 to spread the digital output (i.e., data rate from section (i)), and then shift the spread data by Binary PSK. Consider the transmission takes place over an ideal band limited additive white Gaussian noise (AWGN) channel and the power spectral density of the noise is $N_0 = 1\times 10^{-10}$ W/Hz.

1. What is the chip rate? [3 marks]
2. What is the jamming margin against a continuous tone jammer if the desired error probability is 10^{-4}? [7 marks]
3. What is the minimum amount of power needed at the transmitter in order to maintain a bit error probability of $P_B=10^{-4}$? Assume that, the data is transmitted along a cable that attenuates the signal power by 10dB. [5 marks]

Continued...

Question 3

(a) A baseband digital system that receives a waveforms, $s_1(t) = A\cos\omega_0 t$ *and* $s_2(t) = -A\cos\omega_0 t$ through a channel at a data rate of 1Mbps, and the value of A is 10mW. If the noise power spectral density is N_0=10^{-11} Watt/Hz.

(i) What is the bit error probability of this system? [5 marks]

(ii) Consider the system makes errors at the average rate of 138 errors per day. What should be the system date rate to maintain the error probability found in section (i) [5 marks]

(b) The following signals $s_1(t)$ and $s_2(t)$ are used to carry binary data. Consider that a coherent matched filter used at the receiver side.

$$s_1(t) = 0.5\cos 2000\pi t$$

$$s_2(t) = 0.5\cos 2020\pi t$$

Where the two-sided a white Gaussian noise (AWGN) power spectral density is $N_0/2$ = 0.0001 W/Hz. Assume the symbol duration is T = 0.01s.

(i) Find the probability of bit error. [10 marks]

(ii) How many errors could the detector make in one day? [5 marks]

Continued...

Question 4

(a) If there are N individual stations switching, how many switches and interconnecting wires exist between these stations? If the individual station switching is replaced by central switching, how many switches and interconnecting wires are there between these stations? [4 marks]

(b) A three-stage switching structure is to accommodate N=30 input and 30 output terminals. There are 5 first stage and third stage matrices and 2 intermediate switches.

switches.

(i) Sketch the three-stage switching, and label all the switches. What is the maximum number of connections that can be supported at any given time? Repeat for 3, 6 and 10 intermediate switches. [12 marks]

(ii) Assume that in the multistage switch, an input line is busy 20% of the time. Estimate the percent of time p that a line between the first and second stage is busy, assume that only 3 intermediate switches. [4 marks]

(c) Multimedia University offers 1200 calls between 9:30am to 10:30am with an average call 90-second and loss 22 calls. Find

(i) The traffic offered. [1 mark]
(ii) The traffic carried. [1 mark]
(iii) The traffic lost. [1 mark]
(iv) The grade of service. [1 mark]
(v) The total period of congestion. [1 mark]

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Appendix I

Tabulated values of Q-function

The Q Function (Gaussian Distribution with $\mu = 0$ and $\sigma = 1$)

$$Q(a) = \int_a^\infty \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}}\, dx \qquad Q(a) \cong \frac{1}{a\sqrt{2\pi}} e^{\frac{-a^2}{2}} \text{ for } a \geq 3$$

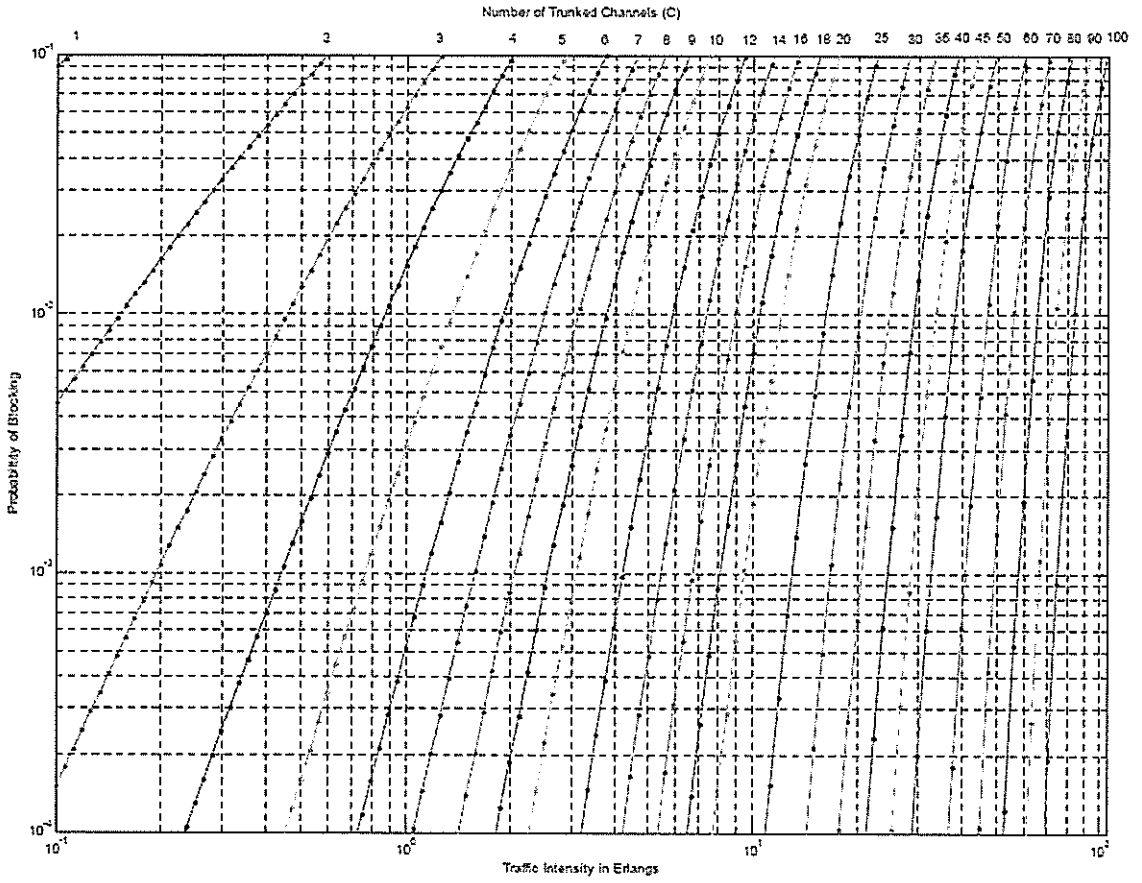
	3rd Significant Digit									
a	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2297	0.2266	0.2236	0.2207	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1094	0.1075	0.1057	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

$Q(a)$	a
10^{-4}	3.73
5×10^{-5}	3.90
10^{-5}	4.27
5×10^{-6}	4.43

$Q(a)$	a
10^{-6}	4.76
10^{-7}	5.20
10^{-8}	5.61
10^{-9}	6.00

Appendix II

Probability of Call Blocking in an Erlang B System


Number of Trunked Channels (C)
1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 25 30 35 40 45 50 60 70 80 90 100
Probability of Blocking
Traffic Intensity in Erlangs

Hexagonal Cell Area = $2.598\ R^2$

Where R is the radius of the cell